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POTATO SPRAYING EXPERIMENTS, 1902-1911

F. C. STEWART, G. T. FRENCH AND F. A. SIRRINE

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*Riverhead, N. Y. †Absent on leave. ‡Connected with the Chautauqua Grape Work.

BULLETIN No. 349.

POTATO SPRAYING EXPERIMENTS, 1902-1911.

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SUMMARY.

This bulletin gives a detailed account of the potato spraying experiments conducted by the Station in 1911 and a summary of results obtained in similar experiments made during the nine years preceding.

In the so-called ten-year experiments the ten-year average increase in yield is as follows:

At Geneva, three sprayings, 69 bu. per acre.

At Geneva, five to seven sprayings, 97.5 bu. per acre.

At Riverhead, three sprayings, 25 bu. per acre.

At Riverhead, five to seven sprayings, 45.7 bu. per acre.

In the farmers' business experiments (6 to 15 each year) the nine-year averages are as follows:

Increase in yield, 36.1 bu. per acre.

Total expense of spraying, $4.74 per acre.

Net profit from spraying, $14.43 per acre.

In 205 volunteer experiments, covering seven years, the average increase in yield was 54.3 bu. per acre.

These experiments demonstrate, beyond doubt, that the spraying of potatoes is highly profitable in New York.

Spraying with bordeaux mixture should be commenced when the plants are six to eight inches high and repeated at intervals of 10 to 14 days throughout the season, making five to seven applications in all. Some poison should be added to the bordeaux whenever bugs or flea beetles are plentiful. The spraying should be very thorough — the more thorough the better.

INTRODUCTION.

Does it pay to spray potatoes in New York? Potato growers have long asked this question. It is well known that in seasons

when blight is destructive spraying will check the blight and considerably increase the yield; but the majority of potato growers have doubted that spraying is profitable on the average. They argue that blight does not appear every year. In some seasons it causes but little if any damage, yet the spraying must be done regularly because it is impossible to foretell the appearance of blight. The result is that in some seasons spraying is profitable while in others it is unprofitable and growers doubt that the aggregate gain will repay the expense of spraying for a series of years.

The Station set out to find an answer to the above question. The investigation was begun in 1902 and concluded in 1911. During ten consecutive years several potato spraying experiments have been made each year. These experiments are of three kinds: (1) Station ten-year experiments (two each year), carried out entirely by the Station; (2) farmers' business experiments (12 to 15 each year), conducted by farmers in coöperation with the Station; (3) farmers' volunteer experiments carried out entirely by farmers. This bulletin gives details of the experiments made in 1911 and a summary of the results obtained in the previous nine years.

Bulletins of this series previously published are:

No. 221. Potato Spraying Experiments in 1902;
No. 241. Potato Spraying Experiments in 1903;
No. 264. Potato Spraying Experiments in 1904;
No. 279. Potato Spraying Experiments in 1905;
No. 290. Potato Spraying Experiments in 1906;
No. 307. Potato Spraying Experiments in 1907;
No. 311. Potato Spraying Experiments in 1908;
No. 323. Potato Spraying Experiments in 1909;
No. 338. Potato Spraying Experiments in 1910.

SUMMARY OF RESULTS OBTAINED IN TEN-YEAR EXPERIMENTS PRIOR TO 1911.

RESULTS IN 1902.

TABLE I.—YIELD BY SERIES AT GENEVA IN 1902.

Series.	Rows.*	Dates of spraying.	Yield per acre.†	
			Bu.	*lbs.*
I.....	1, 4, 7 and 13.....	July 10, 23 and Aug. 12.....	317	41
II.....	2, 5, 8 and 14.....	June 25, July 10, 23, 30, Aug. 12, 26 and Sept. 10.....	342	36
III.....	3, 6, 9 and 15.....	Not sprayed.....	219	4

* Rows 10, 11 and 12 omitted because of probable error.
† The yields given in Tables I to XVIII relate to marketable tubers only.

Increase in yield due to spraying three times, 98½ *bu. per acre.*
Increase in yield due to spraying seven times, 123½ *bu. per acre.*

The unsprayed rows died two weeks earlier than the sprayed rows, owing chiefly to a severe attack of late blight. They were also somewhat injured by flea beetles, but there was no early blight. On unsprayed rows the loss from rot was 7½ per ct.; on sprayed rows only an occasional tuber.

TABLE II.—YIELD BY SERIES AT RIVERHEAD IN 1902.

Series	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	2, 5, 8 and 11.....	May 26, June 20 and July 12.....	295	20
II.....	1, 4, 7 and 10.....	May 26, June 3, 20, 30, July 11, 23 and Aug. 5.	312	35
III.....	3, 6, 9 and 12.....	Not sprayed.....	267	40

Increase in yield due to spraying three times, 27⅔ *bu. per acre.*
Increase in yield due to spraying seven times, 45 *bu. per acre.*

In this experiment there were only traces of early blight and no late blight. The larger yield on sprayed rows was due to partial protection against flea beetles which were rather plentiful at times. There was no rot.

RESULTS IN 1903.

TABLE III.—YIELD BY SERIES AT GENEVA IN 1903.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 14, 28 and Aug. 26.....	262	—
II.....	2, 5, 8, 11 and 14....	July 7, 21, Aug. 7, 21 and Sept. 3.....	292	10
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	174	20

Increase in yield due to spraying three times, 88 *bu. per acre.*
Increase in yield due to spraying five times, 118 *bu. per acre.*

Three sprayings prolonged the life of the plants 11 days; five sprayings, 18 days. There was no early blight and the injury from flea beetles was only slight. Late blight was again the chief enemy. The loss from rot was even less than in 1902.

TABLE IV.—YIELD BY SERIES AT RIVERHEAD IN 1903.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7 and 10.....	June 5, July 22 and Aug. 7.....	246	45
II.....	2, 5, 8 and 11.....	June 5, 24, July 7, 22 and Aug. 7.....	253	10
III.....	3, 6, 9 and 12.....	Not sprayed.....	207	10

Increase in yield due to spraying three times, 39½ *bu. per acre.*
Increase in yield due to spraying five times, 56 *bu. per acre.*

The sprayed rows outlived those unsprayed by several days. Late blight and flea beetles were the chief enemies. Early blight, also, caused slight damage. On the unsprayed rows the loss from rot was 2 per ct.; on those sprayed, practically nothing.

RESULTS IN 1904.

TABLE V.— YIELD BY SERIES AT GENEVA IN 1904.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 13, 27 and Aug. 15.....	344	30
II.....	2, 5, 8, 11 and 14....	July 8, 22 and Aug. 1, 15 and 29.....	386	40
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	153	25

Increase in yield due to spraying three times, 191 *bu. per acre.*
Increase in yield due to spraying five times, 233 *bu. per acre.*

Spraying prolonged the life of the plants 25 days. Late blight was the only trouble. On both sprayed and unsprayed rows there was a little rot at digging time. In storage, the sprayed potatoes rotted most. Spraying materially improved the cooking qualities.

TABLE VI.— YIELD BY SERIES AT RIVERHEAD IN 1904.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7 and 10.....	June 14, July 21 and Aug. 9.....	257	58
II.....	2, 5, 8 and 11.....	June 14, 27, July 11, 26, Aug. 9 and 22.....	297	45
III.....	3, 6, 9 and 12.....	Not sprayed.....	201	25

Increase in yield due to spraying three times, $56\frac{1}{2}$ *bu. per acre.*
Increase in yield due to spraying six times, $96\frac{1}{3}$ *bu. per acre.*

The larger yield on sprayed rows was due chiefly to partial protection against flea beetles which were unusually abundant. Both early and late blight were also present. The loss from rot was 3 per ct. on Series I, 1 per ct. on Series II, and 6 per ct. on Series III.

RESULTS IN 1905.

TABLE VII.— YIELD BY SERIES AT GENEVA IN 1905.

Series.	Rows.*	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	4, 7, 10 and 13.....	July 3, Aug. 7 and 25.....	228	45
II.....	5, 8, 11 and 14.....	June 29, July 13, 27, Aug. 12 and 24.....	241	15
III.....	6, 9, 12 and 15.....	Not sprayed.....	121	52

* Rows 1, 2 and 3 omitted because of error.

Increase in yield due to spraying three times, 107 *bu. per acre.*
Increase in yield due to spraying five times, 119⅓ *bu. per acre.*

From the combined attack of flea beetles, tip burn and late blight the unsprayed rows died fully two weeks earlier than the sprayed ones. Spraying reduced the loss from rot at the rate of 41 bushels per acre. There was no subsequent rot in storage.

TABLE VIII.— YIELD BY SERIES AT RIVERHEAD IN 1905.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	June 14, July 18 and Aug. 11.....	253	—
II.....	2, 5, 8, 11 and 14....	June 14, 30, July 14, 28 and Aug. 11.....	303	41
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	221	38

Increase in yield due to spraying three times, 31⅓ *bu. per acre.*
Increase in yield due to spraying five times, 82 *bu. per acre.*

Late blight caused no injury in this experiment and there was not even a trace of rot. Flea beetles and early blight were the enemies fought.

RESULTS IN 1906.

TABLE IX.—YIELD BY SERIES AT GENEVA IN 1906.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 9, Aug. 10 and 30.....	227	25
II.....	2, 5, 8, 11 and 14....	July 6, 20, Aug. 6, 20 and 21.....	258	40
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	195	40

Increase in yield due to spraying three times, $31\frac{3}{4}$ *bu. per acre.*
Increase in yield due to spraying five times, 63 *bu. per acre.*

Late blight, early blight, flea beetles and tip burn were all factors in this experiment, but none of them caused much damage. Spraying controlled blight and flea beetles completely and tip burn partially. The loss from rot was negligible, only four rotten tubers being found in the entire experiment.

TABLE X.—YIELD BY SERIES AT RIVERHEAD IN 1906.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	June 12, July 18 and Aug. 6.....	172	—
II.....	2, 5, 8, 11 and 14....	June 12, 25, July 10, 25 and Aug. 6.....	203	45
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	150	30

Increase in yield due to spraying three times, $21\frac{1}{2}$ *bu. per acre.*
Increase in yield due to spraying five times, $53\frac{1}{4}$ *bu. per acre.*

In the experiment at Riverhead the principal enemies were late blight and flea beetles, there being a moderate attack of both. Early blight was not sufficiently abundant to cause material injury. There was no loss from rot.

RESULTS IN 1907.

TABLE XI.—YIELD BY SERIES AT GENEVA IN 1907.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 15, Aug. 9 and 24.....	220	15
II.....	2, 5, 8, 11 and 14....	July 15, 24, Aug. 9, 24 and Sept. 17.....	249	50
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	176	10

Increase in yield due to spraying three times, 44 *bu. per acre.*
Increase in yield due to spraying five times, $73\frac{2}{3}$ *bu. per acre.*

Late blight and rot were wholly absent and early blight appeared only in traces. There was some tip burn and a light attack of flea beetles. Considering the seemingly small amount of damage done by blight and insects it is remarkable that spraying should have increased the yield so much.

TABLE XII.—YIELD BY SERIES AT RIVERHEAD IN 1907.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	June 19, July 25 and Aug. 15.....	186	45
II.....	2, 5, 8, 11 and 14....	June 19, July 2, 17, 31, Aug. 15 and 29.....	200	5
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	168	50

Increase in yield due to spraying three times, 18 *bu. per acre.*
Increase in yield due to spraying six times, $31\frac{1}{4}$ *bu. per acre.*

There was some early blight, but no late blight. Flea beetles were plentiful and caused much damage. The larger yield of the sprayed rows is to be attributed to their partial protection against flea beetles and early blight.

RESULTS IN 1908.

TABLE XIII.—YIELD BY SERIES AT GENEVA IN 1908.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 3, 17 and Aug. 3.....	155	40
II.....	2, 5, 8, 11 and 14....	July 3, 17, Aug. 3, 18, Sept. 1, and 16.....	165	10
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	126	10

Increase in yield due to spraying three times, $29\frac{1}{2}$ *bu. per acre.*
Increase in yield due to spraying six times, 39 *bu. per acre.*

There was no early blight, no late blight and no rot. Flea beetles caused slight damage to the unsprayed rows, most of which occurred after September 1st. The chief trouble was tip burn, which was quite severe. The sprayed rows of Series II outlived the unsprayed rows of Series III by about five days owing, apparently, to the smaller amount of tip burn and flea beetle injury on the sprayed rows.

TABLE XIV.—YIELD BY SERIES AT RIVERHEAD IN 1908.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	June 11, July 9 and Aug. 4.....	147	35
II.....	2, 5, 8, 11 and 14....	June 11, 25, July 9, 24 and Aug. 4.....	152	10
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	136	50

Increase in yield due to spraying three times, $10\frac{3}{4}$ *bu. per acre.*
Increase in yield due to spraying five times, $15\frac{1}{3}$ *bu. per acre.*

In this experiment there was some early blight and a moderate attack of flea beetles, but no late blight and no rot. During July considerable damage was done by aphids which were not checked by the spraying.

RESULTS IN 1909.

TABLE XV.— YIELD BY SERIES AT GENEVA IN 1909.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 9, 23 and Aug. 11.....	162	20
II.....	2, 5, 8, 11 and 14....	July 9, 23, Aug. 11, 27, Sept. 10 and 24.....	173	25
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	123	40

Increase in yield due to spraying three times, $38\frac{2}{3}$ *bu. per acre.*
Increase in yield due to spraying six times, $49\frac{3}{4}$ *bu. per acre.*

Early blight, late blight and rot were all absent. Some injury from flea beetles was noticeable throughout the season. After September 1 there was considerable tip burn. As late as September 24 the difference between sprayed and unsprayed rows appeared slight. The sprayed rows held most of their foliage until killed by frost on October 14.

TABLE XVI.— YIELD BY SERIES AT RIVERHEAD IN 1909.

Series.	Rows.	Dates of spraying.	Yield per acre.*	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	June 11, July 16 and 31.....	136	30
II.....	2, 5, 8, 11 and 14....	June 11, 25, July 9, 24, Aug. 6, and 21.....	160	20
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	107	50

* Marketable tubers only. Owing to their small average size it was deemed advisable to make two grades of the marketable tubers; " firsts " which sold for 80 cents per bushel and " seconds " which sold for 40 cents. The increase in yield due to spraying was chiefly in the grade of " firsts," the yields being as follows:

Rows sprayed three times, $75\frac{1}{2}$ bu. " firsts " and $61\frac{1}{2}$ bu. " seconds; " rows sprayed six times, 100 bu. " firsts " and $60\frac{1}{2}$ bu. " seconds; " unsprayed rows, 50 bu. " firsts " and $57\frac{5}{8}$ bu. " seconds."

Increase in yield due to spraying three times, $28\frac{2}{3}$ *bu. per acre.*
Increase in yield due to spraying six times, $52\frac{1}{2}$ *bu. per acre.*

There was a little early blight, but no late blight and no rot. After July 15 the plants suffered from both drought and flea beetles. From this time until the plants were all dead the sprayed rows were noticeably superior to the unsprayed ones. This difference was more marked during the last week in July than on August 21.

RESULTS IN 1910.

TABLE XVII.— YIELD BY SERIES AT GENEVA IN 1910.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 6, 20 and Aug. 3.....	244	30
II.....	2, 5, 8, 11 and 14....	July 6, 20, Aug. 3, 18, Sept. 2 and 19.....	285	25
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	222	35

Increase in yield due to spraying three times, 22 bu. per acre.
Increase in yield due to spraying six times, 63 bu. per acre.

A very little damage was done by flea beetles and early blight. The chief factor was late blight which appeared about the middle of September and wrought considerable havoc in the north one-third of the field. In this region there was, also, some loss from rot — 43 bu. per acre on Series I, 10.8 bu. on Series II and 37.2 bu. on Series III.

TABLE XVIII.— YIELD BY SERIES AT RIVERHEAD IN 1910.*

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I.....	4, 7, 10 and 13.....	June 20, July 16 and Aug. 1.....	163	45
II.....	5, 8, 11 and 14.....	June 20, July 3, 16, Aug. 1 and 13.....	174	22
III.....	6, 9, 12 and 15.....	Not sprayed.....	148	57

* Incorrectly reported in Bulletin 338. Rows 1, 2 and 3 should have been excluded because of their irregular yields due to some other cause than spraying.

Increase in yield due to spraying three times, $14\frac{3}{4}$ bu. per acre.
Increase in yield due to spraying five times $25\frac{1}{2}$ bu. per acre.

The plants suffered severely from drought and were moderately attacked by flea beetles, plant lice and early blight; but late blight and rot were wholly absent.

DETAILS OF THE TEN-YEAR EXPERIMENTS IN 1911.

AT GENEVA.

During 1911 the experiment at Geneva was carried out in practically the same manner as in previous years. As usual, there were fifteen rows 290.4 feet long by three feet wide. Planting was done by hand on May 22 and 23. The variety was Rural New Yorker No. 2. Each row received ten pounds (500 lbs. per acre) of chemical fertilizer applied by hand as uniformly as possible in the open furrow at planting time. The soil was of the same general character as that used for the experiment during the past eight years, namely, a rather heavy gravelly clay loam with good surface drainage. Because of the very dry weather which prevailed for about seven weeks after planting the young potato plants made a slow, spindling growth at first and never attained large size. However, the unfavorable conditions at the start were partly offset by an unusually long growing season — May 22 to October 27 — with an abundance of rain in the last few weeks.

The five rows constituting Series I were sprayed three times with bordeaux — July 6, 20 and August 17.

The five rows constituting Series II were sprayed seven times with bordeaux — July 6, 20, August 4, 17, 31, September 15 and 30.

The five rows constituting Series III (check) were not sprayed at all with bordeaux.

Colorado potato beetles or "bugs" were eliminated from the experiment by means of paris green which was applied over the entire field twice and to portions of the check rows a third time. The first two applications were made on the dates of the first two sprayings (July 6 and 20), the paris green being mixed with the bordeaux used on Series I and II while on the check rows (Series III) it was applied with lime water. The third application of paris green (made August 17) was required only on certain portions of the check rows which were being slightly injured by bugs. In all cases the paris green was used at the rate of one pound to fifty gallons.

In each spraying the bordeaux was applied uniformly and very thoroughly with a knapsack sprayer, the quantity varying from about 100 gallons in the first spraying to about 250 gallons per acre in the later ones. The bordeaux used contained six pounds of copper sulphate in each 50 gallons and lime somewhat in excess of the quantity required to satisfy the potassium ferrocyanide test. No attempt was made to spray the undersurface of the leaves.

Until nearly the middle of September the unsprayed rows appeared to be in as good condition as the sprayed ones. On September 15 a contrast was observed for the first time. The foliage of the rows sprayed every two weeks was perfect while that of the unsprayed rows began to show tip burn. Although it was not marked there was certainly a difference. From this time until about October 15, when the unsprayed rows were entirely dead, the contrast between sprayed and unsprayed rows became gradually more and more pronounced. The condition of the rows sprayed three times was intermediate between that of unsprayed rows and rows sprayed every two weeks. On all rows, the plants in the north half of the field died somewhat earlier than in the south half. Viewed from the south end on October 23 the rows sprayed seven times appeared to be in nearly full foliage; while rows sprayed three times showed only an occasional green branch; and the check rows were entirely dead. The first killing frost came on the night of October 27, at which time the rows sprayed seven times were still quite green over the south half of their length though nearly dead over the north half.

There was no late blight whatever, only a very little early blight and a very little flea beetle injury. The unsprayed rows were affected by no disease of any consequence except tip burn and even of that there was only a moderate amount. As the plants were still partially alive twenty weeks after planting it is clear that they could not have been very much injured by anything. Yet spraying increased the yield at the rate of 93 bu. per acre. Plainly, we have here a striking example of the beneficial influence of bordeaux in the absence of diseases and insect enemies. Of course,

the unusually long growing season gave the bordeaux an opportunity to exert its full influence. Had frost come on October 1, as frequently happens, the difference in yield between sprayed and unsprayed rows would have been much smaller; and had frost come on September 14, when potato fields in many localities in the State were killed, the gain from spraying would probably have been very small.

Several persons who saw the experiment during October after the contrast had become marked raised the question as to whether the sprayed rows were increasing their yield at that time. They must have been increasing their yield rapidly else they could not have outyielded the unsprayed rows by as much as 93 bu. per acre.

Apparently, the increased yield of the sprayed rows was due chiefly to the larger average size of the tubers. On the rows sprayed seven times the tubers were quite large — so large, in fact, that some difficulty might have been experienced in selling them at full price in the regular potato market.

The potatoes were dug by hand and the product of each row sorted and weighed as in previous years. The yield by rows is shown in the following table:

TABLE XIX.— YIELDS IN THE EXPERIMENTS AT GENEVA IN 1911.

Row.	Treatment.	Yield per row.*		Yield per acre.			
		Marketable.	Culls.	Marketable.		Culls.	
		Lbs.	*Lbs.*	*Bu*	*lbs.*	*Bu.*	*lbs.*
1	Sprayed 3 times	297	4	247	30	3	20
2	Sprayed 7 times	364	6	303	20	5	00
3	Unsprayed	205½	9½	171	15	7	55
4	Sprayed 3 times	278	8	231	40	6	40
5	Sprayed 7 times	350	6	291	40	5	00
6	Unsprayed	226	9	188	20	7	30
7	Sprayed 3 times	265½	5	221	15	4	10
8	Sprayed 7 times	301	5½	250	50	4	35
9	Unsprayed	208	10½	173	20	8	45
10	Sprayed 3 times	245	8½	204	10	7	5
11	Sprayed 7 times	332	4	276	40	3	20
12	Unsprayed	198	6	165	00	5	00
13	Sprayed 3 times	266	10½	221	40	8	45
14	Sprayed 7 times	323	6	269	10	5	00
15	Unsprayed	†275	8	229	10	6	40

* Rows 290.4 feet long by 3 feet wide, making the area of each row exactly one-fiftieth acre.

† At the time of the second spraying, Row 15 was sprayed with bordeaux by mistake. This probably explains, in part, why it yielded so much more than the other check rows; but there must have been, also, some other disturbing factor else it would not have outyielded Row 13 sprayed three times.

The five rows sprayed three times constitute Series I and the average yield of these rows makes the yield for Series I. The yields given for Series II and III have been computed in the same way. The yield by series is shown in the following table:

TABLE XX.— YIELD BY SERIES AT GENEVA IN 1911.

Series.	Rows.	Dates of spraying.	Yield per acre.*	
			Bu.	*lbs.*
I.....	1, 4, 7, 10 and 13....	July 6, 20 and Aug. 17.....	225	15
II.....	2, 5, 8, 11 and 14....	July 6, 20, Aug. 4, 17, 31, Sept. 15 and 30....	278	20
III.....	3, 6, 9, 12 and 15....	Not sprayed.....	185	25

* Marketable tubers only.

Increase in yield due to spraying three times, 40 *bu. per acre.*
Increase in yield due to spraying seven times, 93 *bu. per acre.*

AT RIVERHEAD.

With minor variations the experiment at Riverhead was carried out in the same manner as the one at Geneva. The potatoes were of the variety Carman No. 1. They were planted April 14. The soil was sandy loam.

The five rows of Series I were sprayed with bordeaux mixture three times — May 30, June 24 and July 12.

The five rows of Series II were sprayed with bordeaux mixture five times — May 30, June 14, 28, July 12 and 26.

The five rows of Series III (check), received no bordeaux.

Bugs were controlled with paris green used at the rate of one and one-half pounds to fifty gallons. On Series I and II it was applied with the bordeaux three times and on Series III twice (June 24 and July 12), with lime water.

In this experiment flea beetles were plentiful. There was, also, a little early blight, but no late blight and no rot. The chief cause of the low yield was the severe drought which brought about the premature death of the plants on all three series. Table XXI shows the yield by rows and Table XXII the yield by series.

TABLE XXI.—YIELDS IN THE EXPERIMENT AT RIVERHEAD IN 1911.

Row.	Treatment.	Yield per row.*		Yield per acre (computed).			
		Marketable.	Culls.	Marketable.		Culls.	
		Lbs.	*Lbs.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*
1	Sprayed 3 times	177	5	147	30	4	10
2	Sprayed 5 times	168	3	140	—	2	30
3	Unsprayed	199.5	4	166	15	3	20
4	Sprayed 3 times	161.5	4	134	35	3	20
5	Sprayed 5 times	174.5	6.5	145	25	5	25
6	Unsprayed	161	5	134	10	4	10
7	Sprayed 3 times	133.5	7	111	15	5	50
8	Sprayed 5 times	152.5	6	127	5	5	—
9	Unsprayed	164.5	6.5	137	5	5	25
10	Sprayed 3 times	152	8	126	40	6	40
11	Sprayed 5 times	151	14	125	50	11	40
12	Unsprayed	129	9	107	30	7	30
13	Sprayed 3 times	183	12	152	30	10	—
14	Sprayed 5 times	157	14	130	50	11	40
15	Unsprayed	146	12	121	40	10	—

* Rows 290.4 feet long by 3 feet wide, making the area of each row exactly one-fiftieth acre.

TABLE XXII.—YIELD BY SERIES AT RIVERHEAD IN 1911.

Series.	Rows.	Dates of spraying.	Yield per acre.	
			Bu.	*lbs.*
I	1, 4, 7, 10 and 13	May 30, June 24 and July 12	134	30
II	2, 5, 8, 11 and 14	May 30, June 14, 28, July 12 and 26	133	50
III	3, 6, 9, 12 and 15	Not sprayed	133	20

Increase in yield due to spraying three times, $1\frac{1}{3}$ *bu. per acre.*
Increase in yield due to spraying five times, $\frac{1}{2}$ *bu. per acre.*

In all our experience with potato spraying experiments this is the only instance in which five thorough sprayings with bordeaux mixture have failed to increase the yield. What may have been the cause we do not know. Perhaps the severe drought had something to do with it. There is no reason to believe that the unsprayed rows had any advantage over the sprayed rows.

SUMMARY OF RESULTS OBTAINED IN THE TEN-YEAR EXPERIMENTS.

The following table shows the results obtained in the ten-year experiments at Geneva and Riverhead:

TABLE XXIII.—SUMMARY OF THE TEN-YEAR EXPERIMENTS.

Year.	At Geneva.		At Riverhead.	
	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.	Gain per acre due to spraying every two weeks.	Gain per acre due to spraying three times.
	Bu.	*Bu.*	*Bu.*	*Bu.*
1902	123.5	98.5	45	27.7
1903	118	88	56	39.5
1904	233	191	96	56.5
1905	119	107	82	31.5
1906	63	32	53	21.5
1907	73.7	44	31	18
1908	39	29.5	15.7	10.7
1909	49.7	38.7	52.5	28.7
1910	63	22	25.5	14.7
1911	93	40	.5	1.1
Average	97.5	69	45.7	25

The ten-year experiments are now concluded. They have been carried out during ten consecutive years very nearly as planned. Three times (twice at Geneva and once at Riverhead) it has been necessary to reject the data from certain parts of the experiment field because of inequalities due to other causes than spraying; but there has been no crop failure or serious accident to break the continuity of the experiments.

One striking feature of Table XXIII is the difference between the gains obtained at Geneva and those obtained at Riverhead. At Geneva, the increase in yield due to spraying is more than double what it is at Riverhead. It is probable that this difference is due partly to differences in the temperature and rainfall in the two localities and partly to difference in soil. Throughout the whole ten years the Riverhead experiment has been on light, sandy soil while the experiment at Geneva has been on rather heavy clay loam.

The results of these experiments, considered in connection with other experiments and observations made by the writers, indicate that the average benefit from spraying potatoes in New York may vary very widely in different localities and on different soils. The average increase of 45 bu. per acre obtained at Riverhead is probably the minimum average increase to be expected from thorough spraying since potatoes are rarely planted on lighter, drier soil than that used for the experiment at Riverhead. On the other hand, the maximum average is probably over 100 bu. per acre. Many thousands of acres are planted on heavy soils in low situations where the ravages of blight and rot are considerably greater than on such land as was used for the experiment at Geneva. What the mean average for the State may be cannot be stated, even approximately. It can only be said to be large — somewhere between 50 and 100 bu. per acre.

Five to seven sprayings in the course of the season gave much better results than three sprayings. Undoubtedly, the three sprayings would have made a better showing had they been applied later in the season; but this was impracticable because of the necessity of early spraying to control "bugs." All of our experience in spraying potatoes with bordeaux mixture indicates that the more frequently and thoroughly the plants are sprayed the better it is for them and the larger will be their yield of tubers.

In these experiments we have been able to greatly reduce the ravages of early blight, late blight, rot, tip burn and flea beetles, but have not succeeded in completely controlling any of them in times of severe attack.

FARMERS' BUSINESS EXPERIMENTS.

During the season of 1911 fourteen farmers in different parts of the State conducted business experiments for the Station. The object of these experiments is to determine the actual profit in spraying potatoes under farm conditions. The methods employed were essentially the same as in previous years. An accurate record was kept of all of the expense of spraying, including labor,

chemicals and wear of machinery. In each experiment a strip of a few rows was left unsprayed for comparison.

"Spraying," as used in this bulletin, means the application of bordeaux mixture exclusively. The application of paris green or arsenite of soda in lime water is not called spraying.

Whenever "arsenite of soda" is mentioned it should be understood to mean the stock solution prepared by the Kedzie formula — one pound white arsenic, four pounds sal soda and one gallon of water boiled together twenty minutes.

By "test rows" is meant the rows used in determining the amount of the increase in yield due to spraying. These are, usually, the middle unsprayed row and the second sprayed row on either side.

Unless otherwise stated, the yields given are for marketable tubers only.

The price used in computing the value of the increased yield is, in every case, the market price for potatoes in the locality where the experiment was made on the date on which the test rows were dug.

In ten of the experiments a few rows were double-sprayed; that is, at each spraying these rows were treated twice. The object of this was to determine whether more thorough spraying would be profitable.

THE LANCASTER EXPERIMENT.

Conducted by F. W. Handy, Lancaster, N. Y. Six acres of potatoes were sprayed four times (July 31, Aug. 7, 16 and 24) with bordeaux mixture, formula 4¾-6-50. The spraying was done with a one-horse, four-row "Iron Age" sprayer carrying one nozzle per row. The potato field was about 100 yards from the water supply. The water was pumped by a gasoline engine. Four rows 664 feet long by 32 inches wide were left unsprayed for a check. Owing to the absence of bugs it was unnecessary to use any poison. On each side of the check a strip of four rows was double-sprayed at each spraying. Apparently, the plants were not injured by blight, yet an occasional rotten tuber was found at digging time.

The items of expense were as follows:

150 lbs. copper sulphate @ 5.5 cts	$8 25
200 lbs. lime	80
24 hrs. labor for man and horse @ 25 cts	6 00
Allowance for wear of sprayer	2 00
Total	$17 05

Average expense of spraying, $2.84 per acre.

The test rows yielded as follows:

Two double-sprayed rows, 811 lbs.= 166.2 bu. per acre.

Two single-sprayed rows, 714 lbs.= 146.4 bu. per acre.

Two check rows, 735.5 lbs.= 150.8 bu. per acre.

Single-spraying resulted in a loss of 4.4 bu. per acre, while double-spraying gave a gain of 15.4 bu. per acre.

The market price of potatoes being sixty cents per bushel, the total loss per acre from single-spraying was $5.48, while from double-spraying there was a net profit of $3.56 per acre.

THE BATAVIA EXPERIMENT.

Conducted by G. A. Prole, Batavia, N. Y. Thirty acres of potatoes were sprayed four times with a two-horse, four-row "Iron Age" sprayer carrying one nozzle per row. The dates of spraying were July 7, 20, August 1 and 15. Water was obtained from a well about fifty rods from the field. It was pumped by a windmill. In the first and third sprayings arsenite of soda was used with the bordeaux at the rate of four quarts to sixty gallons. The check consisted of a strip of three unsprayed rows 953 feet long and 2.8 feet apart. These were treated twice (July 7 and August 1) with arsenate of lead to control bugs. The plants grew to large size. They became considerably affected with tip burn. Traces of late blight were discovered September 26, but no appreciable damage was done by it and no rotten tubers were found at digging time. Sprayed and unsprayed rows appeared equal throughout the season.

The expense account contained the following items:

384 lbs. copper sulphate @ 6 cts.	$23 04
3 bu. lime @ 25 cts.	75
32 lbs. white arsenic @ 8 cts.	2 56
64 lbs. sal soda @ 1½ cts.	96
80 hrs. labor for man and horse @ 30 cts.	24 00
Arsenate of lead.	50
Wear on sprayer.	5 00
Total . . .	$56 81

The test rows (variety Sir Walter Raleigh), yielded as follows:

Two sprayed rows, 1,474 lbs.= 200.4 bu. per acre.

Middle check row, 682 lbs.= 185.5 bu. per acre.

Gain from spraying, 14.9 bu. per acre.

Potatoes being worth sixty cents per bushel, the gain of 14.9 bu. has a value of $8.94. After subtracting $1.88, the expense of spraying, there remains *a net profit of $7.06 per acre.*

THE ALBION EXPERIMENT.

Conducted by Ora Lee, Jr., Albion, N. Y. Seventeen acres of potatoes (variety Sir Walter Raleigh), were sprayed seven times between June 27 and August 29. The spraying outfit consisted, essentially, of a 250-gallon tank and a Friend pump worked by a gasoline engine. It was mounted on a four-wheeled cart drawn by two horses. Ten rows were covered at each passage. The water required was pumped by a windmill from a well only a few rods from the potato field. Arsenate of lead, at the rate of 20 lbs. to 250 gallons, was used with the bordeaux in the first, second and fourth sprayings. On the same dates the same poison (with water) was applied to the check which consisted of four rows 962 feet long by 32 inches wide. Ten rows on one side of the check were double-sprayed. During the last three weeks of growth the sprayed rows made a better appearance than the unsprayed rows. Double-sprayed rows held their foliage better than single-sprayed rows. The principal disease was tip burn, which was very prevalent.

The items of expense were as follows:

1180 lbs. copper sulphate @ $4.33 per cwt	$51 10
4 bbls. lump lime @ $1.15	4 60
10 sacks (40 lbs. each) ground lime @ 25 cts	2 50
300 lbs. arsenate of lead @ 8 cts	24 00
122½ hrs. man labor @ 15 cts	18 38
152 hrs. horse labor @ 10 cts	15 20
Wear of sprayer	25 00
Gasoline and oil	4 00
Total	$144 78

The yields were as follows:

Four double-sprayed rows, 3,485 lbs.= 246.5 bu. per acre.

Four single-sprayed rows, 2,948 lbs.= 208.5 bu. per acre.

Four check rows, 2,779 lbs.= 196.6 bu. per acre.

The above figures show that single-spraying, costing $8.52 per acre, increased the yield only 11.9 bu. per acre worth $7.14. Therefore, it was done at *a loss of $1.38 per acre.* On the other hand, double-spraying resulted in a net profit of $12.90 per acre.

THE ANDOVER EXPERIMENT.

Conducted by J. M. Greene & Son, on a field of 8.5 acres at Andover, N. Y. Four rows were left unsprayed for a check. A strip of four rows adjoining the check on either side was single-sprayed with bordeaux five times (See diagram on next page). The remainder of the field was double-sprayed five times. Messrs. Greene were led to double-spray so much of their acreage because of the results of an experiment which they made in 1910.[1]

In 1911 the spraying was done very nearly as in 1910. The sprayer used was a two-horse "Watson" covering four rows at each passage. One nozzle per row was used in the first three sprayings and two nozzles per row in the last two sprayings. Water for the preparation of the bordeaux was taken from a spring about ten rods from the potato field. Owing to the absence of bugs it was unnecessary to use any poison even on the check rows. Flea beetles and blight, also, were almost entirely absent and only a few rotten tubers were found at digging time. Apparently, the plants suffered from nothing which spraying might be expected to prevent. There was little if any contrast in appearance between sprayed and unsprayed rows.

The items of expense were as follows:

215 lbs. copper sulphate @ 5 cts.	$10 75
215 lbs. lime @ 1 ct.	2 15
Labor for man and team and allowance for wear of sprayer, estimated[2] @ 80 cts. per acre for double-spraying.	34 00
Total	$46 90

Expense of making five double-sprayings, $5.52 per acre.

Expense of making five single-sprayings, $2.76 per acre.

The plants were killed by frost on September 14. Had they been permitted to complete their growth the sprayed rows would probably have made a better showing. The small differences in yield of the different test rows was due, probably, to something else than spraying. This is shown by the fact that one of the check rows outyielded the other by 44 lbs. or 19.8 bu. per acre.

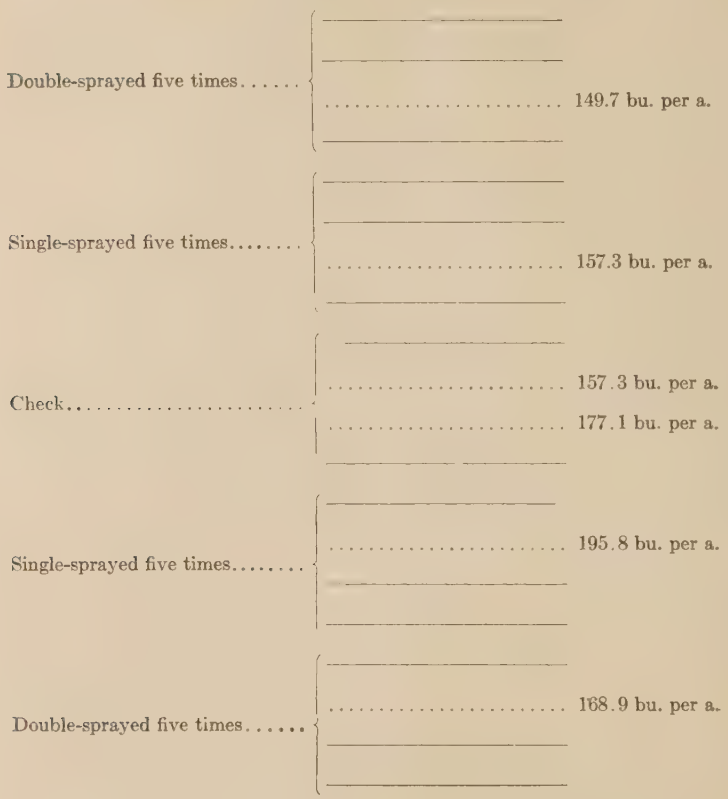
In the accompanying diagram the test rows[3] are indicated by dotted lines and followed by their rate of yield.

[1] Reported in Bul. 338 of this Station, pages 134–135.

[2] Messrs. Greene think this estimate rather high. It is unfortunate that an actual record was not kept.

[3] The test rows were 540 ft. long by 3 ft. wide.

Diagram I.— Showing Location and Yields of Test Rows in the Andover Experiment.



Average yield of double-sprayed rows, 159.3 bu. per acre.
Average yield of single-sprayed rows, 176.6 bu. per acre.
Average yield of check rows, 167.2 bu. per acre.
Gain from single-spraying, 9.4 bu. per acre.
Loss from double-spraying, 7.9 bu. per acre.

With potatoes selling at 55 cts. per bushel, 9.4 bu. would have a value of $5.17. Subtracting from this the expense of spraying, $2.76 per acre, there remains $2.41 per acre as the net profit from single-spraying five times. Computed in a similar manner the *loss* from double-spraying five times was $9.86 per acre.

THE PHELPS EXPERIMENT.

Conducted by J. A. Page, Phelps, N. Y. Fourteen acres of potatoes (in three fields) were sprayed four times. The spraying was done with a two-horse, five-row Brown sprayer carrying one nozzle per row. In each field there was a check of five rows. At one side of each check a strip of five rows was double-sprayed. Tip burn was severe in both fields and in the west field there was also a little early blight, but there was no late blight and few flea beetles. Bugs were kept under control by two applications of arsenate of lead. In the east field spraying made little if any difference in the appearance of the foliage, but in the west field a contrast between sprayed and unsprayed rows was noticeable.

The expense of spraying was as follows:

250 lbs. copper sulphate @ 5 cts	$12 50
2½ bbls. lime @ $1.50	3 75
210 lbs. arsenate of lead @ 8 cts	16 80
40 hrs. labor for man and team @ 35 cts	14 00
Wear of sprayer	10 00
Total	$57 05

In the east field the rows were 674 feet long by 3 feet wide. Double-sprayed rows yielded at the rate of 108.6 bu., single-sprayed rows 87.6 bu. and check rows 98.4 bu. per acre. In the west field the rows were 1757 x 3 ft. Dougle-sprayed rows yielded at the rate of 123.9 bu., single-sprayed rows 109.4 bu. and check rows 96.4 bu. per acre.

Hence, single-spraying gave a loss of 10.8 bu. in the east field and a gain of 13 bu. per acre in the west field, making an average gain of 1.1 bu. per acre. Double-spraying gave a gain of 10.2 bu. in the east field and 27.5 bu. in the west field, making an average gain of 18.8 bu. per acre.

Potatoes being worth 70 cts. per bushel, single-spraying resulted in a loss of $3.39 per acre while double-spraying gave an average net profit of $4.84 per acre.

THE DRYDEN EXPERIMENT.

Conducted by D. R. Trapp, Dryden, N. Y. The experiment included three fields containing eight acres of potatoes. Five applications of bordeaux were made with a two-horse, four-row "Iron Age" sprayer carrying two nozzles per row. Bordeaux of the 7-9-55 formula was used in the first three sprayings while in the last two sprayings 8-12-55 bordeaux was used. In the first two sprayings paris green was added to the bordeaux at the rate of three pounds to 55 gallons for the control of bugs. In one field a strip of three unsprayed rows was left for a check. These rows were dusted twice with paris green and flour, which gave good protection against bugs. The test rows were of the variety Gold Coin. They suffered severely from tip burn and flea beetles, but were unaffected by blight. Neither the tip burn nor the flea beetles were materially checked by spraying. There was very little contrast between sprayed and unsprayed rows.

The expense of spraying was as follows:

222 lbs. copper sulphate @ 5 cts.	$11 10
300 lbs. lime	1 90
43 lbs. paris green @ 20 cts.	8 60
40 hrs. labor for man and team @ 40 cts.	16 00
Wear on sprayer	5 00
Total	$42 60

Expense of spraying one acre five times, $5.32.

Expense of spraying one acre once, $1.07.

The test rows (300 ft. x 32 in.) yielded as follows:

East sprayed row, 210 lbs.= 190.6 bu. per acre.

West sprayed row, 206 lbs.= 187 bu. per acre.

Average yield of sprayed rows, 188.8 bu. per acre.

Middle check row, 183 lbs.= 166.1 bu. per acre.

Gain from spraying, 22.7 bu. per acre.

Potatoes being worth 55 cents per bushel at time of digging, the spraying resulted in a net profit of $7.16 per acre.

THE CORTLAND EXPERIMENT.

Conducted by G. H. Hyde, Cortland, N. Y. A field of eight acres was sprayed four times — seven and one-third acres single-sprayed and two-thirds of an acre double-sprayed. A strip of three unsprayed rows separated the single-sprayed portion of the field from the double-sprayed portion. The bordeaux (6-6-60 formula) was applied with a one-horse, four-row "Watson" sprayer carrying two nozzles per row. Paris green was used with the bordeaux in the first two sprayings. It was also used on the check rows twice, with water. Before the end of the season the unsprayed rows became quite conspicuous owing to their inferior condition due, chiefly, to the ravages of flea beetles. The spraying checked the flea beetles considerably. There was no blight and very little tip burn.

The expense account contained the following items:

200 lbs. copper sulphate @ 5½ cts	$11 00
200 lbs. lime	1 40
24 lbs. paris green @ 21 cts	5 04
24 hrs. labor for man and horse @ 30 cts	7 20
Wear of sprayer	6 00
Total	$30 64

Expense per acre for four single-sprayings, $3.54.

Expense per acre for four double-sprayings, $7.08.

The test rows (400 x 3 ft.) yielded as follows:

One double-sprayed row, 339 lbs.= 205.1 bu. per acre.

One single-sprayed row, 271 lbs.= 164 bu. per acre.

One check row, 144.6 bu. per acre.

Gain from double-spraying, 60.5 bu. per acre.

Gain from single-spraying, 19.4 bu. per acre.

Potatoes being worth 60 cts. per bushel, 19.4 bu. would have a value of $11.64. Subtracting from this the expense of single-spraying, $3.54 per acre, there remains a net profit of $8.10 per acre. Similarly, 60.5 bushels would be worth $36.30 from which there must be deducted $7.08, leaving a net profit of $29.22 per acre for double-spraying.

THE CASSVILLE EXPERIMENT.

Conducted by P. S. Doolittle, Cassville, N. Y. The experiment field contained six acres of potatoes (variety Carman No. 3), which were sprayed five times with a two-horse, seven-row Brown sprayer, carrying one nozzle per row. The check consisted of a strip of seven unsprayed rows 681 feet long. On either side of the check a strip of seven rows was double-sprayed as shown in the diagram on the opposite page. The bordeaux used was of the 5-5-50 formula. Paris green (1½ lbs. to 50 gals.) was used with the bordeaux in the first two sprayings. On the same dates (July 8 and 20), the check rows were treated with the same quantity of paris green applied with water. Tip burn was severe and there were some flea beetles, but both early and late blight were absent and there was no rot. Considering that there was no blight and that the plants were killed by an early frost on September 14 the large difference in yield between sprayed and unsprayed rows is remarkable. However, the experiment seems to have been a fair one in all respects.

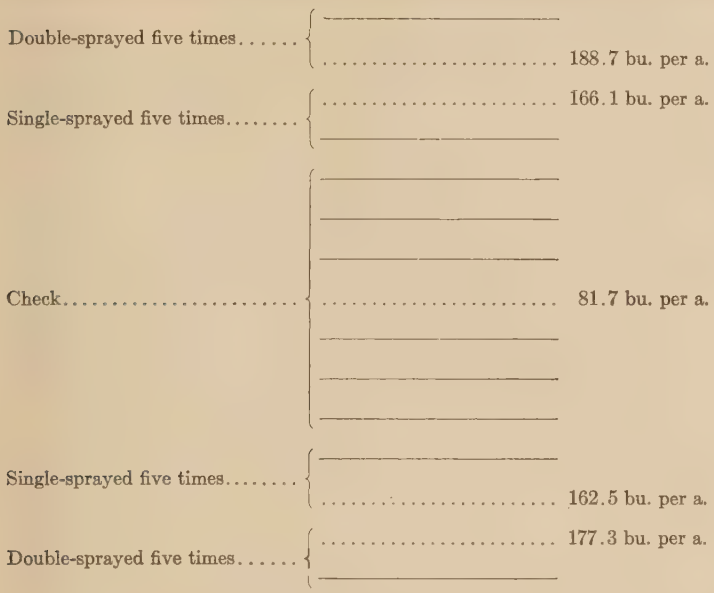
The items of expense were as follows:

175 lbs. copper sulphate @ 5½ cts	$9 63
180 lbs. lime @ 1¼ cts	2 25
22 lbs. paris green @ 22 cts	4 84
21½ hrs. man labor @ 20 cts	4 30
18 hrs. labor for team @ 20 cts	3 60
Wear of sprayer	6 00
Total	$30 62

Expense per acre, for five sprayings, $5.10.

The accompanying diagram shows the location of the test rows with reference to each other. They are indicated by dotted lines and followed by their yield.

DIAGRAM 2.— SHOWING LOCATION AND YIELDS IN THE CASSVILLE EXPERIMENT.



Average yield of double-sprayed rows, 183 bu. per acre.

Average yield of single-sprayed rows, 164.3 bu. per acre.

Yield of middle check row, 81.7 bu. per acre.

Gain due to single-spraying, 82.6 bu. per acre.

Gain due to double-spraying, 101.3 bu. per acre.

With potatoes selling at 70 cts. per bushel, single-spraying gave a net profit of $52.72 per acre while double-spraying gave a net profit of $60.71 per acre.

THE OGDENSBURG EXPERIMENT.

Conducted by Andrew Tuck, Ogdensburg, N. Y. About 4.6 acres of potatoes were sprayed six times between July 18 and September 4. A one-horse, four-row Aspinwall sprayer was used. One nozzle per row was used in the first three sprayings and two nozzles per row in the last three. A strip of three unsprayed rows constituted the check. In all six sprayings paris green was used with the bordeaux at the rate of three pounds to fifty gallons. Paris green in water was applied to the check rows three times by means of a sprinkling pot without any apparent injury to the foliage. Four rows on one side of the check were double-sprayed. Some contrast appeared between the check and the sprayed rows due to the check rows being more injured by tip burn, flea beetles and bugs. On the check rows bugs were not as well controlled as they should have been to make the experiment entirely fair.

The following items appear in the expense account:

105 lbs. copper sulphate @ 7½ cts	$7 88
105 lbs. lime	1 10
60 lbs. paris green @ 25 cts	15 00
36 hrs. labor for man and horse @ 30 cts	10 80
Wear of sprayer	1 00
Total	$35 78

Expense of single-spraying six times, $7.78 per acre.

Expense of double-spraying six times, $15.56 per acre.

The test rows (variety, Green Mountain; 171 x 3 ft.) yielded as follows:

One double-sprayed row, 138 lbs.= 195.3 bu. per acre.

Two single-sprayed rows, 253 lbs.= 179 bu. per acre.

One check row, 103 lbs.= 145.8 bu. per acre.

Gain from single-spraying, 33.2 bu. per acre.

Gain from double-spraying, 49.5 bu. per acre.

Market price of potatoes, $1.00 per bushel.

Net profit from single-spraying, $25.42 per acre.

Net profit from double-spraying, $33.94 per acre.

THE CHATEAUGAY EXPERIMENT.

Conducted by O. Smith & Son, Chateaugay, N. Y. Twelve acres of potatoes were sprayed four times with a one-horse, four-row "Iron Age" sprayer. Two unsprayed strips of three rows each were left for checks.

Two rows on each side of both checks were double-sprayed.

The bordeaux was made by the 6-6-50 formula. To each fifty gallons of bordeaux mixture used in the first three sprayings there were added three pounds of paris green and two quarts of arsenic-sal soda solution for the control of bugs. The checks were treated four times with paris green. In Test No. 1 the test rows were of the variety New National; in Test No. 2 they were of the variety Sulphic Beauty. There were some flea beetles and considerable tip burn, particularly in Test No. 1, but there was no blight. In both tests there was a slight contrast between sprayed and unsprayed rows.

The items of expense were as follows:

260 lbs. copper sulphate @ 6⅔ cts	$17 40
2½ bbls. lime @ $1.08	2 70
53 lbs. paris green @ 25 cts	13 25
18 lbs. white arsenic @ 6½ cts	1 17
72 lbs. sal soda @ 2½ cts	1 80
43 hrs. labor for man and horse @ 30 cts	12 90
Total	$49 22

Expense of spraying, $4.10 per acre.

The yields were as follows:

Test No. 1. Rows 1,066 x 3 ft.

One double-sprayed row, 407 lbs.= 92.4 bu. per acre.

One single-sprayed row, 526 lbs.= 119.4 bu. per acre.

One check row, 396 lbs.= 89.9 bu. per acre.

Test No. 2. Rows 353 x 3 ft.

Two double-sprayed rows, 181 lbs.= 62 bu. per acre.

Two single-sprayed rows, 216 lbs.= 74 bu. per acre.

Two check rows, 160 lbs.= 54.8 bu. per acre.

Upon averaging the results of the two tests it is found that single-spraying gave a gain of 24.4 bu. per acre and double-spraying only 4.9 bu. per acre. The net profit from single-spraying was $11.76 per acre and the loss from double-spraying $5.02 per acre. The cause of these irregular results is unknown.

THE PLATTSBURGH EXPERIMENT.

Conducted by Pardy Brothers, Plattsburgh, N. Y. Thirteen acres of potatoes were sprayed all over three times and about four-sevenths of the field (including the test rows) were sprayed a fourth time. A strip of six unsprayed rows constituted the check. Bordeaux mixture of the 4-5-50 formula was used. It was made with water pumped by hand from a well about one-fourth mile from the potato field. The sprayer used was a two-horse, six-row "Aroostook" carrying one nozzle per row. Before the experiment was commenced the entire field was treated twice with a strong solution of arsenite of soda in water containing as much lime as could be forced through the nozzles. This was done in an attempt to control flea beetles and leaf hoppers. As might have been expected, the plants were considerably injured, but this does not affect the experiment since the test rows were all treated alike. The plants were somewhat affected by tip burn, but there was no blight.

The items of expense were as follows:

210 lbs. copper sulphate @ $6.25 per cwt	$13 12
Lime	1 00
257 lbs. sal soda @ 1¼ cts	3 22
20 lbs. arsenate of lead @ 11 cts	2 20
54 lbs. white arsenic @ 9 cts	4 86
50 hrs. labor for man @ 15 cts	7 50
40 hrs. labor for team @ 20 cts	8 00
Wear on sprayer	8 00
Total	$47 90

Expense of spraying one acre four times, $4.68.

The test rows (var. Rose of Erin) yielded as follows:

Two sprayed rows, 224 lbs.= 69 bu. per acre.

Two check rows, 199 lbs.= 61.3 bu. per acre.

Gain from spraying, 7.7 bu. per acre.

The low yields were due, largely, to the severe drought and early frost. With potatoes at 75 cts. per bushel spraying apparently resulted in a net profit of $1.09 per acre.

THE GREENWICH EXPERIMENT.

Conducted by P. C. Billings, Greenwich, N. Y. Four and one-half acres of potatoes were double-sprayed four times with a two-horse six-row "Aroostook" sprayer carrying one nozzle per row. At each spraying a portion of the field was double-sprayed so that total amount of work done was equal to spraying 25.8 acres once. The last spraying, made September 12, could have been of little or no benefit as the plants were killed by frost on September 14. In different sprayings the strength of the bordeaux varied from 5-5-50 to 7½-7½-50. The check consisted of three rows 736 feet long by 2.9 feet wide. For the control of bugs paris green, at the rate of one pound to fifty gallons, was applied with the bordeaux in the first three sprayings. The check rows received a single application of paris green yet they were not injured by bugs. On account of a severe drought the plants were much affected with tip burn. Blight and flea beetles were absent. The superior condition of the sprayed rows as compared with the check rows indicated that spraying checked the tip burn very materially.

The expense account contained the following items:

99 lbs. copper sulphate @ 6½ cts	$6 43
99 lbs. lime @ 1 ct	99
10 lbs. paris green @ 20 cts	2 00
13 hrs. labor for man @ 15 cts	1 95
10 hrs. labor for team @ 30 cts	3 00
Wear on sprayer	5 00
Total	$19 37

Expense of four double-sprayings, $6.40 per acre.

The test rows (variety Noxall) yielded as follows:

Two double-sprayed rows, 492 lbs.= 83.6 bu. per acre.

One single-sprayed row, 182 lbs.= 61.9 bu. per acre.

Gain from spraying, 21.7 bu. per acre.

Potatoes being worth 70 cts. per bushel at digging time the net profit from spraying in this experiment was $8.79 per acre.

THE GLEN HEAD EXPERIMENT.

Conducted by G. T. Powell, Glen Head, Long Island. Fifteen acres of potatoes were sprayed five times (June 14, 29, July 14, 20, and August 7) with bordeaux applied by means of a one-horse, four-row "Spramotor" sprayer carrying two nozzles per row. Four rows were left unsprayed for a check. Four rows on each side of the check were double-sprayed. Arsenite of soda was used with the bordeaux in the first two sprayings at the rate of 3 qts. of the stock solution to 50 gals. of bordeaux. The check was kept free from bugs by one application of lead arsenate. Flea beetles were numerous and there was much tip burn but no blight. A marked contrast between the sprayed and unsprayed rows indicated that spraying had checked both tip burn and flea beetles, but when the yields were taken very little difference was found between the single-sprayed rows and the check. This leads us to suspect that, in some way, the experiment was unfair.

The items of expense were as follows:

450 lbs. copper sulphate @ 5 cts.	$22 50
Lime	6 00
100 lbs. sal soda @ 1½ cts.	1 50
40 lbs. white arsenic @ 3 cts.	1 20
75 hrs. labor for man and horse @ 25 cts.	18 75
Wear of sprayer	5 00
Total	$54 95

Expense per acre for five sprayings, $3.66.

Expense of spraying one acre once, 73 cents.

The test rows (variety Green Mountain) yielded as follows:

Average yield of two double-sprayed rows, 166.5 bu. per acre.

Average yield of two single-sprayed rows, 147.7 bu. per acre.

Yield of one check row, 145.5 bu. per acre.

Gain due to double-spraying, 21 bu. per acre.

Gain due to single-spraying 2.2 bu. per acre.

Potatoes being worth $3 per barrel of 174 lbs. (= $1.03 per bu.), single-spraying resulted in a loss of $1.40 per acre, while double-spraying gave a net profit of $14.31 per acre.

THE JAMESPORT EXPERIMENT.

Conducted by Henry A. Hallock, Jamesport, Long Island. Fifteen acres of potatoes were sprayed five times between June 9 and July 29. The sprayer used was a two-horse, four-row "Iron Age" sprayer, carrying one nozzle per row. The bordeaux was made by the 7-4-50 formula. Four unsprayed rows were left for a check. Four rows adjoining the check on one side were double-sprayed. There being no bugs it was unnecessary to apply poison to the check rows, but, on the sprayed portion of the field, arsenite of soda was used with the bordeaux twice at the rate of four quarts of the stock solution to 50 gallons of bordeaux for the control of flea beetles which were fairly plentiful. There was no late blight and only traces of early blight. At no time during the season was there any marked difference between sprayed rows and the check.

The items of expense were as follows:

1200 lbs. copper sulphate @ 5¼ cts.	$63 00
600 lbs. lime	4 00
200 lbs. sal soda @ 1 ct.	2 00
100 lbs. white arsenic @ 5 cts.	5 00
50 hrs. labor for man @ 20 cts.	10 00
50 hrs. labor for team @ 45 cts.	22 50
Wear on sprayer	5 00
Total	$111 50

Expense of spraying one acre once, $1.48.

Expense of spraying one acre five times, $7.40.

The test rows (variety Green Mountain) yielded as follows:

Two double-sprayed rows, 1,261 lbs.= 221.1 bu. per acre.

Two single-sprayed rows, 1,150 lbs.= 201.6 bu. per acre.

Two check rows, 1,100 lbs.= 192.9 bu. per acre.

Gain from double-spraying, 28.2 bu. per acre.

Gain from single-spraying, 8.7 bu. per acre.

With potatoes at 90 cts. per bushel single-spraying resulted in a net profit of 43 cts. per acre, while double-spraying gave a net profit of $10.58.

SUMMARY OF BUSINESS EXPERIMENTS IN 1911.

TABLE XXIV.—SHOWING RESULTS OF BUSINESS EXPERIMENTS IN 1911.

Experiment.	Area sprayed.	Number of times sprayed.	Increase or decrease in yield per acre.	Total cost of spraying per acre.	Cost per acre for each spraying.	Net profit or loss per acre.
	A.		*Bu.*			
Cassville	6	5	82.6	$5 10	$1 02	$52 72
Ogdensburg	4.6	6	33.2	7 78	1 30	25 42
Chateaugay	12	4	24.4	4 10	1 02	11 76
Greenwich	4.5	8*	21.7	6 40	80	8 79
Cortland	8	4	19.4	3 54	89	8 10
Dryden	8	5	22.7	5 32	1 07	7 16
Batavia	30	4	14.9	1 88	47	7 06
Andover	8.5	5	9.4	2 76	55	2 41
Plattsburgh	13	4	7.7	4 68	1 17	1 09
Jamesport	15	5	8.7	7 40	1 48	43
Albion	17	7	11.9	8 52	1 22	—1 38
Glen Head	15	5	2.2	3 66	73	—1 40
Phelps	14	4	1.1	4 16	1 04	—3 39
Lancaster	6	4	—4.4	2 84	71	—5 48

* Four double-sprayings.

Average increase in yield per acre, 18.2 *bushels.*
Average net profit per acre, $8.09.

SUMMARY OF BUSINESS EXPERIMENTS, 1903–1911.

TABLE XXV.—SHOWING RESULTS OF BUSINESS EXPERIMENTS IN 1903–11.

Year.	Number of experiments.	Total area sprayed.	Average increase in yield per acre.	Average total cost of spraying per acre.	Average cost per acre for each spraying.	Average net profit per acre.
		A.	*Bu.*			
1903	6	61.2	57	$4 98	$1 07	$23 47
1904	14	180	62.2	4 98	93	24 86
1905	13	160.7	46.5	4 25	98	20 04
1906	15	225.6	42.6	5 18	985	13 89
1907	14	152.75	36.8	5 90	1 18	17 07
1908	14	200.25	18.5	4 30	92	8 53
1909	12	203.14	24.4	4 15	835	9 55
1910	12	218.5	19.1	4 04	90	4 39
1911	14	161.6	18.2	4 87	96	8 09

Average increase in yield for nine years, 36.1 *bu. per acre.*
Average net profit for nine years, $14.43 *per acre.*

REMARKS ON RESULTS OF BUSINESS EXPERIMENTS.

It is unfortunate that the business experiments were not commenced at the same time as the ten-year experiments in order that

they might have covered the same period; but it is deemed unnecessary to continue them further.

Like the ten-year experiments the business experiments have shown widely varying results in different localities. As a rule, spraying has been more profitable on damp, loam soils than on dry, sandy soils; and better results have been obtained in sheltered than in exposed situations. Also, the fertility of the land and the variety of potato are factors. Most important of all is the thoroughness of spraying.

Some of the experiments have been conducted quite carefully and others carelessly. In several cases there have occurred puzzling differences in yield which were probably due to some other cause than spraying. Although care has been taken in the location of the test rows soil differences have often been a disturbing factor. Sometimes the expense accounts have not been kept properly. In short, the manner in which the experiments have been conducted is far from satisfactory. Nevertheless, it is believed that the results obtained show, approximately, the profit from spraying as practiced by the better class of potato growers in New York. That spraying is profitable there can no longer be any doubt. Even if we make the generous allowances of 30 per ct. for errors there remains an average net profit of $10 per acre. Moreover, there is good reason to believe that the average net profit would have been considerably larger had the spraying been properly done in all of the experiments. In most cases the spraying was not sufficiently thorough. Evidence of this is seen in the results of double-spraying as compared with single-spraying.

The writers hold that these experiments have given a very definite answer to the question, Does it pay to spray potatoes? *The spraying of late potatoes in New York is highly profitable.* No one who grows potatoes extensively can afford to neglect spraying.

SINGLE- VERSUS DOUBLE-SPRAYING.

Observations on the farmers' business experiments led us to suspect that, in most cases, the spraying was not done thoroughly

enough to secure the maximum net profit. In order to get some information on this point arrangements were made with several of the experimenters to double-spray a few rows at each spraying. In some cases a strip on either side of the check was double-sprayed; in others, double-spraying was done on only one side of the check. The double-spraying consisted simply in going over a few rows a second time on the date of each spraying. In computing the net profit from double-spraying it has been assumed that the expense of double-spraying is exactly double that of single-spraying.

Five such experiments were made in 1910 and ten in 1911. The results of the former were published in Bulletin 338 and of the latter in this bulletin, but in order that they may be more readily comprehended they have been tabulated in the accompanying table. The first five experiments given in the table are those made in 1910; the others were made in 1911. Under the heading "Increase or decrease in yield" there are three columns. The first of these relates to single-spraying, the second to double-spraying while the third shows how much doubling the spraying increased the yield over single-spraying. A minus sign indicates a decrease in yield.

The figures given in the last column under "Profit or loss" show how doubling the spraying affected the net profit as compared with single-spraying. It will be observed that double-spraying proved profitable in eleven cases and unprofitable in the other four, the average result being a net profit of $4.44 per acre. The average increase in yield was increased from 20.2 bu. for single-spraying to 34.7 bu. per acre for double-spraying.

Considering that these results were obtained in dry seasons when spraying was less profitable than usual the showing made by double-spraying is highly creditable. The writers are convinced that most potato growers will find it to their advantage to spray more thoroughly than they have been doing in the past.

TABLE XXVI.— SHOWING RESULTS OF DOUBLE-SPRAYING AS COMPARED WITH SINGLE-SPRAYING.

Location of experiment.	Times sprayed.	Increase or decrease in yield.			Expense of single-spraying.	Market price of potatoes.	Profit or loss.
		Single-spraying.	Double-spraying.	Difference.			
		Bu.	*Bu.*	*Bu.*	*Per acre.*	*Cts.*	
Andover	4	33.5	88.4	54.9	$3 58	35	$15 63
Sterling Station	5–7*	—0.9	33.7	34.6	4 28	35	7 83
Glen Head	4	27.9	41.4	13.5	2 87	69	6 44
Jamesport	4	46.7	41.7	—5	4 53	60	—7 53
Southampton	4	7	—26.5	—33.5	2 72	55	—21 19
Cortland	4	19.4	60.5	41.1	3 54	60	21 12
Glen Head	5	2.2	21	18.8	3 66	103	15 71
Albion	7	11.9	49.9	38	8 52	60	14 28
Jamesport	5	8.7	28.2	19.5	7 40	90	10 15
Lancaster	4	—4.4	15.4	19.8	2 84	60	9 04
Ogdensburg	6	33.2	49.5	16.3	7 78	100	8 52
Phelps	4	1.1	18.8	17.7	4 16	70	8 23
Cassville	5	82.6	101.3	18.7	5 10	70	7 99
Andover	5	9.4	—7.9	—17.3	2 76	55	—12 27
Chateaugay	4	24.4	4.9	—19.5	4 10	65	—16 78
Averages	.....	20.2	34.7	14.5	.....	.....	4 44

* There were three tests — one sprayed five times, the others seven times.

VOLUNTEER EXPERIMENTS.

From 1904 to 1910, inclusive, the Station collected and recorded the results of 205 volunteer experiments conducted by farmers in various parts of the State. These experiments were carried out entirely by farmers themselves. Although the data relating to these experiments are probably less reliable than those given for the farmers' business experiments yet they have some value. The details of the experiments have been published in previous bulletins. Only a summary of the results need be given here.

TABLE XXVII.— SHOWING RESULTS OF VOLUNTEER EXPERIMENTS, 1904–1910.

Year.	Number of experiments.	Total area sprayed.	Average gain per acre due to spraying.		Average market price per bushel of potatoes at digging time.
		A.	*Bu.*	*lbs.*	*Cts.*
1904	41	364	58	28	43.5
1905	50	407	59	32	57.0
1906	62	598	53	6	44.5
1907	24	264	30	28	58
1908	11	74	66	18	66
1909	12	115	44	22	51
1910	5	218	68	—	45

Average gain for seven years (205 experiments), 54.3 bu. per acre.

POTATO TROUBLES IN NEW YORK IN 1911.

Over the greater part of the State the growing season of 1911 was very dry. Consequently, late blight (*Phytophthora infestans*) occurred very sparingly. It made its appearance in a few localities, but came too late to cause material injury to the foliage. Neither was there much loss from rot although traces of it were found in a considerable number of fields in central and western New York. Early blight (*Alternaria solani*), also, was scarce. As in 1910, the leading troubles of potato foliage were flea beetle injury and tip burn. Tip burn, especially, was very prevalent.

DIRECTIONS FOR SPRAYING.

In general, commence spraying when the plants are six to eight inches high[1] and repeat the treatment at intervals of 10 to 14 days in order to keep the plants well covered with bordeaux throughout the season. During epidemics of blight it may be advisable to spray as often as once a week.[2] Usually, six applications will be required. The bordeaux should contain four pounds of copper sulphate to each fifty gallons in the first two sprayings and six pounds to fifty gallons in subsequent sprayings.[3]

[1] On Long Island an earlier spraying is sometimes necessary to protect the young plants from flea beetles which attack them severely while they are coming up. For the best success in the control of bugs it is necessary to spray with bordeaux and poison just as soon as a majority of the first brood are hatched. Usually, this occurs when the plants are six to eight inches high. Spray applied three days or more before the bugs hatch will fail to kill many of them, because, in the interval the plants make considerable new growth upon which the bugs can feed with impunity and cause considerable damage before it is time to make the next regular spraying.

[2] On the south shore of Long Island between Southampton and Amagansett this is frequently necessary.

[3] It can not be definitely stated what formula is the best one to use. Much depends upon the quantity used per acre and the manner of its application. Weak bordeaux applied in the form of fine spray which covers the plants thoroughly may give better results than stronger bordeaux carelessly applied in the form of coarse spray. Both the cost of chemicals and the expense of application must be taken into consideration. It is plain, however, that the mixture should be strengthened as the season advances and the danger from blight increases. None of the ready-made bordeaux mixtures on the market are as good as the home-made bordeaux. Neither can the lime-sulphur solution be profitably substituted for bordeaux in spraying potatoes (See Bul. 347 of this Station). In the preparation of bordeaux the writers prefer to use stone lime rather than any of the "prepared" limes.

Whenever bugs or flea beetles are plentiful add one or two pounds of paris green, two quarts of arsenite of soda stock solution or three to five pounds of arsenate of lead to the quantity of bordeaux required to spray an acre.

Thoroughness of application is to be desired at all times, but is especially important when flea beetles are numerous or the weather favorable to blight. The more frequently and thoroughly the plants are sprayed the better. There is no danger of injuring the foliage by too much spraying. Using the same quantity of bordeaux, frequent light applications are likely to be more effective than heavier applications at long intervals; e. g., when a horse power sprayer carrying but one nozzle per row is used, it is better to go over the plants once a week than to make a double spraying once in two weeks. In the first two sprayings, while the plants are small, one nozzle per row may be sufficient; but when the plants become large at least two nozzles per row should be used. Large vines are especially liable to blight and should be sprayed very thoroughly. Such vines will be somewhat injured by the wheels of the sprayer, but the benefit from spraying will far outweigh the damage done.

A single spraying is better than none and will usually be profitable, but more are better. Spraying may prove highly profitable even though the blight is only partially prevented. It is unsafe to postpone spraying until blight appears. Except, perhaps, on small areas, it does not pay to apply poison alone for bugs. When it is necessary to fight insects bordeaux mixture and poison should be used together. For the best results, spraying should be continued as long as the plants live. It is a mistake to discontinue spraying because the weather is dry and no blight present. A late attack of blight may result in heavy loss from rot. As a rule, those who spray most obtain the largest net profit.

Acknowledgment. Throughout the ten years during which this investigation has been in progress many farmers have had a part in the work and given very material assistance. The writers heartily thank these gentlemen for the service they have rendered.